Design for Disassembly in the Built Environment

The Environmental Protection Agency's Office of Solid Waste and Emergency Response initiated a series of innovative pilot projects to test ideas and strategies for improved environmental and public health results. This series of fact sheets highlights the innovative approaches, results, and environmental and economic benefits from the pilot projects that may be replicated across various sectors, industries, communities, and regions.

PROJECT DESCRIPTION/INNOVATION

EPA awarded an Innovation grant to the Community Housing Resource Center (CHRC) to extend the design for disassembly (DfD) concept to the construction of residential housing. If properly applied, a DfD building vastly reduces waste at the end of life and even prolongs the life of a building by allowing for changes. Though the DfD concept had been used in commercial building applications where adaptable and movable space is preferred, this concept was completely new to residential homes. The project sought to: formulate innovative DfD principles, design and build a case study house, document research and results, and promote the incorporation of these principles into future housing design.

BACKGROUND

In 2002, the U.S. Geological Survey estimated that 60 percent of all materials flow in the U.S. economy (excluding food and fuel) is consumed by the construction industry. Preliminary estimates from the EPA in 2003 showed that 91 percent of all construction-related waste produced annually in the U.S. was a result of renovations and demolitions, representing as much as 30 percent of all waste produced in the U.S. Of the total building-related waste generated, EPA estimated that only 40 percent was reused, recycled, or sent to waste-to-energy facilities, while the remaining 60 percent was sent to landfills.

In *Toward a New Metropolis: The Opportunity to Rebuild America*, a discussion paper prepared for The Brookings Institution Metropolitan Policy Program in 2004, it was estimated that the total built space in this country will grow from 296 billion square feet in 2000 to 427 billion square feet in 2030. Of this growth, 82 billion square feet of building will come from the replacement of existing building space and 131 billion will be new construction, totaling 213 billion square feet of new built space.

This estimate means that 27 percent of existing buildings in 2000 will be replaced by 2030, and that more than 50 percent of buildings in 2030 will have been built since 2000. Instead of construction materials ending up as waste once these building outlive their usefulness, DfD can be incorporated to recover them from new construction, future renovations and removals.

Project Highlights

- Building an average single-family home generates between 10,000-25,000 pounds of construction and demolition debris. Yet, fewer than eight 30-gallon garbage bags were filled with debris during the yearlong construction of the three bedroom, 2.5 bath, 3,000 square foot DfD model house.
- This case study led to the development of the best practices toolkit for DfD in residential construction, *Design for Disassembly in the Built Environment: A Guide for Closed-Loop Design and Building.*
- The pilot project served as a learning tool for testing the viability of DfD in the market, both by working with a traditional construction company and by selling the home on the open real estate market.
- Based on the pilot's success, EPA granted the Community Housing Resource Center $100,000 for an additional DfD home.

If residential housing designed from 2000 to 2050 allows for recovery of just 25 percent of construction debris, the resulting materials would be enough for nearly two-thirds of the housing units built during the following 50 years.

PROJECT SUMMARY

In 2004, the Community Housing Resource Center (CHRC), working in conjunction with the Hamer Center for Community Design Assistance at Pennsylvania State University and EPA Region 4, assembled a group of industry experts for a two-day design meeting in Atlanta, Georgia to develop a design plan for the case study home based on DfD principles. The meeting led to the development of a model for residential DfD construction projects called the "Anywhere House."

Prior to finalizing the design plan, a project site in Atlanta was selected for the DfD case study home—an undeveloped lot located in a dense urban setting within the historic Martin

Luther King, Jr. District. The nearby King Memorial, shops and restaurants added to the sustainability of the project as a viable home site, and created the potential for a pedestrian friendly urban lifestyle.

Based on the Anywhere House model, construction of the two-story, 3,000 square foot DfD residential home began in spring 2006 and was completed in June 2006. The pilot documented all research, design, and case study results. In addition, the project team created educational materials promoting the green approach for residential building design and conducted outreach that included discussions with representatives from the American Institute of Architects' Committee on the Environment, the Used Building Materials Association, and the U.S. Green Building Council.

RESULTS

The Pilot formulated design for disassembly (DfD) principles to design and build the first known residential DfD case study home, demonstrating that residential homes can be designed both for increased longevity and for future disassembly and building material reuse. Though DfD was a new concept in residential housing, the model DfD home was constructed with current building materials and using conventional building methods. Choosing to work within accepted trade practices and with convenient materials allowed the pilot case study method to be easily replicated and spread throughout the industry without calling for large-scale changes in residential construction methods.

The case study home featured DfD elements such as repositionable interior walls, which can be removed and relocated without creating any waste or compromising structural integrity; and a disentangled Heating, Ventilation and Air Conditioning (HVAC) system, in which the HVAC system is split into two smaller pumps for heating and air conditioning, one for each floor. This HVAC approach reduces the size of the units and the necessary ductwork, and eliminates the typical entanglement of ducts in the structural core of the second floor, where it would be sealed in by drywall finishes or the sub-floor. This design means that interior wall modifications are less invasive and more easily completed.

The home also included DfD features that focused on the use of green building materials, such as structural insulated panel (SIP) walls made from agricultural fiber that provide a renewable framing and insulating alternative to foam core and wall-to-wall bamboo flooring. Bamboo is not only less expensive and more resilient than typical wood flooring, but it also takes only a few years to reach maturity and can be harvested again and again from the same plant. In addition, the bamboo flooring was installed before the interior walls, which means the floors will not need to be re-patched when walls are moved.

Innovation Pilot Partners

Lead: Community Housing Resource Center

Sponsor: U.S. EPA Region 4

Other Partners:

- Center for Maximum Potential Building Systems
- Design AVEnues
- EHDD Architects
- Hamer Center for Community Design at Pennsylvania State University
- Georgia Department of Natural Resources

Additional Information

OSWER Innovation Projects:
www.epa.gov/oswer/iwg/pilots/

OSWER Innovation Deconstruction Success Story:
www.epa.gov/oswer/iwg/

EPA Resource Conservation Challenge – Environmentally Friendly Design:
www.epa.gov/osw/rcc/resources/elements/design.htm

EPA Region 4 Construction and Demolition Debris:
www.epa.gov/region4/waste/rcra/cdhome.htm

City of Mesa, AZ Household Hazardous Waste Collection Events: www.mesaaz.gov/waste/HHW.aspx

Lifecycle Building Challenge – Resources:
www.lifecyclebuilding.org/resources.php

2010 UPDATE

The Design for Deconstruction principles developed through the DfD pilot have had far-reaching impacts—becoming widely recognized templates for architects, engineers, academia, and other stakeholders. These principles were used to formulate the design of the Chartwell School in Seaside, California, a project that incorporated deconstruction methods such as modular framing and visible utility networks. The momentum for DfD practices created by this pilot also led to creation of the Life Cycle Building Challenge, an annual competition for innovative projects that conserve construction and demolition materials and reduce greenhouse gas emissions by designing buildings for adaptability and disassembly. In addition, the Center for High Performance Schools in California, which oversees the nation's first green building rating program for K-12 schools, added DfD criteria to its rating system based on both the DfD pilot and the Chartwell School project.